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SYSTEM FOR MONITORING AND REGULATING FUEL CONCENTRATION IN
AN ANOLYTE
(SISTEMA KONTROLYA I REGULIROVANIYA KONTSENTRATSII TOPLIVA V
ANOLITE)

Abstract

The invention pertains to electric power generation, to systems for monitoring and regulating the condition of electrochemical generators in particular. The aim of the invention is to improve the accuracy of maintaining a predetermined concentration of fuel and to simplify the system. The system contains a fuel cell with load and a fuel pump, which is automatically controlled by a system that monitors and regulates the fuel concentration in the anolyte. As the indicator of concentration the system uses the parameter of short circuit current, determined by the divider unit, to the input of which the measured values of load voltages are supplied when an additional resistance is switched on and off, that is for controlled disturbances of the generator current. One illustration.

The invention pertains to sources of electrical current, specifically to devices that provide automatic delivery of fuel to a fuel cell battery with compensation for lowered fuel concentration.

The aim of the invention is to improve accuracy in maintaining a given fuel concentration and to simplify the power generating section of the system.

A functional diagram of the fuel concentration monitoring and regulating system in the anolyte is shown in the drawing.

The system contains a fuel cell (TE) 1, load resistor 2, additional resistor 3, switching unit 4, timing oscillator 5, series resonant LC-loop 6, measurement resistor 7, amplitude detector 8, low pass filter 9, square-law function generator 10, divider unit 11, comparison unit 12, concentration set-point device 13, regulator 14 and fuel pump 15.

The system works in the following manner.

In steady-state mode of the fuel cell 1 at the frequency of the timing oscillator one hooks up the supplemental resistor 3 through the switching unit 4 in parallel with the load resistor 2. The supplemental resistor greatly exceeds in magnitude the load resistance.

As a result, periodic fluctuations of the current are created, which passes through the fuel cell, the size of which is selected to be so small that the fuel cell parameters remain practically unchanged within their range.

By using the resonant series LC-loop 6, tuned to the frequency of the timing oscillator 5, a voltage drop is produced at the measurement resistor 7, whose amplitude is proportional to the change of the output voltage of the fuel cell, which is due to hooking up the supplemental resistor 3. The size of the amplitude is measured by the amplitude detector 8 and is supplied to the input of the divider 11. The square of the fuel cell voltage is fed to the other input of this same divider.

The quotient U^2/U_A produced at the output of module 11, where U is the fuel cell voltage, U_A is the amplitude of the voltage at resistor 7, is proportional to the short circuit current of the fuel cell for values of its emf and internal resistance, which correspond to the existing concentration of the fuel and conditions of products in the anolyte near the electrodes.

The index of fuel concentration deviation from the assigned value is the signal at the output of comparison unit 12. This signal influences, via the regulator, the fuel pump 15, which changes the fuel concentration to the required value when the short circuit current of the fuel cell becomes equal to the value assigned by module 13.

One can justify the validity of the above statement relative to the quotient at the output of the divider by solving the system of equations for the voltage at the fuel cell output with the supplemental resistor disconnected from and connected to the fuel cell (U_1 and U_2 respectively). For the condition that $R_n \gg R_N$, where R_n is the size of the supplemental resistance 3, connected in parallel to the load resistance 2 (R_N), the short circuit current ($I_{s.c.}$) of the fuel cell is calculated from the formula

$$I_{s.c.} = E/R_{\text{fuel cell input}},$$

Where E is the electromotive force (emf) of the fuel cell,
One obtains the following result of the calculations:

$$I_{s.c.} = 1/R_n \times U_1/U_1 - U_2$$

Returning to the functional diagram of the monitoring and regulating system and considering that $U_1 - U_2 \ll U_1$, we note that the series connected filter 9 and the square-law function generator 10 in practice generate U_1 , and the resonant loop 6, measurement resistor 7 and the amplitude detector 8 generate a signal that is proportional to $U_1 - U_2$. Consequently, their quotient at the output of divider 11 actually is proportional to the short circuit current of the fuel cell.

In this system an improvement of fuel concentration maintenance accuracy is ensured by the use of the fuel cell short circuit current as the concentration indicator, which:

Is directly related to the main parameters of the fuel cell as the source of electric power (emf) and to the internal resistance;

Is a generalized indicator of the fuel cell condition, because the emf and internal resistance (when they are used independently) characterize different aspects of the fuel cell condition;

Is the most sensitive to a change of fuel concentration (reduced fuel concentration reduces the emf and increases the internal resistance, because their quotient changes to an even greater degree);

Is determined in the system independently of the fuel cell load;

Characterizes the important indicator of the fuel cell, as its load capacity (similar to checking the electrochemical storage batteries by using a high-rate discharge tester, but without consuming a lot of current).

Effectiveness of the system for monitoring and regulating the fuel concentration is determined by the possibility of optimizing the operating conditions of new and future sources of electric power – electrochemical generators – by increasing the efficiency, reducing the fuel consumption, and increasing the operating lifetime. In studying different fuel ingredients the proposed system allows one to quickly find the combination for which the load capacity of a fuel cell is maximum.

CLAIMS

The system for monitoring and regulating fuel concentration in the anolyte, which includes a fuel cell with load, switching unit, timing oscillator, comparison unit with concentration set-point device, regulator and fuel pump is characterized by the fact that in order to improve the accuracy of maintaining a certain fuel concentration and to simplify the power generating part of the system, it additionally includes a divider, square-law function generator, low pass filter, series resonant LC-loop, amplitude detector, measurement and supplemental resistors, whereby the first electrode of the fuel cell is connected to a common bus, and the second electrode is connected to the load resistance and to the inputs of the switching unit, the series resonant LC-loop, and low pass filter, the output of which is connected via the square-law function generator to the first input of the divider, the second input of which is connected via the amplitude detector to the common point of the resonant LC-loop and the measurement resistor, connected by the second end to the common bus. The first and second inputs of the comparison unit are connected to the outputs of the divider and the concentration set-point device respectively, and its output is connected through the regulator to the fuel pump. The switching unit is connected by its control input to the output of the timing oscillator, and by its output it is connected to the supplemental resistor, the second end of which is connected to the second end of the load resistance and to the common bus.